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Smallholders' Adaptations to the Effects of Climate Change: The Sustainability of Leasehold Riverbed Farming in the Terai

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The effects of climate change already impact production and the livelihoods of marginal farmers in the Terai of Nepal. Leasehold riverbed vegetable farming is an innovative agricultural technology maximizing marginal land use and contributing to increasing landless and land-poor household's food security. This study quantifies the economic, environmental, social, and technological sustainability of riverbed farming using an analytical framework for the assessment of agricultural technologies developed by SATNET Asia (Innovation Platform for Food and Nutrition Security). A case study of riverbed farmers in Kailali and Kanchanpur districts, Far-Western Nepal, validates riverbed farming as an economically, environmentally, socially, and technologically sustainable agricultural technology that increases marginal farmers' options for adapting to the effects of climate change.

Introduction

Leasehold riverbed vegetable farming is an innovative agricultural technology maximizing marginal land use in the Terai of Nepal. It enables landless and land-poor households to access unused marginal land, seasonally dry riverbeds, for the market-oriented production of gourds. This study examines the sustainability of leasehold riverbed farming for landless and land-poor households using SATNET Asia's analytical framework for the assessment of agricultural technologies (Kriesemer 2012).

The analytical framework of SATNET Asia, an innovation network for food security and poverty reduction which builds on FAO's definition of sustainable agricultural as "environmentally non-degrading, technically appropriate, economically viable and socially acceptable" (FAO 1988), introduces a composite sustainability indicator system that quantifies four aspects: an agricultural system's economic, environmental, social, and technological sustainability. Using SATNET's framework, this study measured a total of 24 indicators from the four areas. (for a full list of indicators, see Kriesemer 2012: 28). Economic indicators quantify gross agricultural margin and

income generated per hour worked; environmental indicators include resource usage rates, the percentage of off-farm inputs, and impacts on natural biological processes; social indicators measure the job creation rate and share of female adopters; and technical indicators assess the financial and physical capital required to begin riverbed farming and its ease of learning, use, and maintenance.

Research was conducted in the Terai, whose inhabitants are confronting challenges to their food security that are emblematic of problems smallholders around the world face, especially in view of the impacts of climate change. Production pressure on arable land is increasing due to population growth (Agostinucci 2008) and increasingly erratic hydrological cycles (Dulal 2010). The Terai, which covers 23% of Nepal's territory, is home to almost 50% of its population (MOHP 2011). Due to migration from the hills and mountains, where human and natural environmental impacts are increasingly rendering arable lands infertile (Upreti 2002), the rate of population increase is higher in the Terai than in the other areas of Nepal (MOHP 2011, Shrestha 2009). Being the flattest and most temperate part of the country, it is the area most suited to agriculture, cultivating 56% of the total land under production in Nepal (IFPRI 2012). There is little scope for expansion of arable land in the Terai – most suitable land is already being used for production, and much of the remaining areas are the last preserves of the vast forests that covered the area 50 years ago (IFPRI 2012, Khatka 2010). The warming of the Himalayas has already significantly impacted agricultural production in the Terai due to the upstream-downstream connections of the regional water cycle (Dulal 2010, Hobbs 2009). Increasingly erratic weather patterns and regional hydrological systems mean that farmers in the Terai face higher risks from environmental shocks (Dulal 2010) and larger pressure to adapt to producing on marginal lands or under less than optimal conditions. Climate-induced extreme events such as flash floods contribute to the over-sedimentation of fertile fields, while the increased water and sediment volume contained in the river water means large movements of the riverbed from wet season to wet season.

The two areas that served as the focus of this study, Kailali and Kanchanpur districts, are in the Far Western Terai, which faces specific regional challenges that lead to its consistently emerging as one of the most disadvantaged regions in a national comparison. The Far West has a poverty occurrence rate of 46% and an average yearly income of $750 per household, as compared to the national averages of 30% and $2,295 (IFAD 2013a). Its geographic remoteness from the capital and the large cities of the East (only 2 of the 10 largest cities in Nepal are in the West) highlight the West's lacking infrastructure and access to larger markets. In addition to infrastructural

challenges, the 94% of households participating in agriculture in the Far West (UNFCO 2010) face higher risks due to environmental shocks. The weather is rougher and less predictable in the West, with the length of the wet season, total precipitation, and reliability of monsoon rains all decreasing from east to west (Tiwari 2005). In Kailali, the 52% of households considered landless or land-poor (owning 0.05 – 0.15 ha of land) are food secure for less than 3 months each year (Nepali 2011). These, the most vulnerable households, constituted the focus of this study.

Material and Methods

Based on SATNET's analytical framework and indicator system, a case study of the sustainability of leasehold riverbed vegetable farming for landless and land-poor farmers was conducted in Kailali and Kanchanpur districts of Far-Western Nepal (80°03' - 81°18' E longitude, 28°22' - 29°08' N latitude). Using a questionnaire, 318 riverbed farmers were interviewed in 12 groups on 6 river systems (Doda, Banhara, Kanara, Khutiya, Mohana, Sunbara). The questions covered aspects addressed by SATNET's indicator system. A detailed harvest sheet for selected farmers provided qualitative data. Key informant interviews were held with representatives of the local government and organizations involved in riverbed farming. Using the agricultural assessment framework developed by SATNET (Kriesemer 2012), indicator results were analyzed as to their sustainability.

Results and Discussion

Economically, riverbed farming is an activity that contributes significantly to increasing farmers' incomes and shows a rate of return per hour of time invested that is standard for local agricultural wages. Farmers earn an average of $2,478 per hectare, which translates to $335.66 per household farming the standard 4 kattha (1,352m²) plot. The per person income of $1.48 per hour labor time is on par with average local agricultural wages. Since multiple (average: 3) people from each household work on the riverbed plots, the income accumulates within the households. Compared to the regional average yearly household income of $750, riverbed farming households earn, on average, almost half that in one season. In the short term, extra income is spent on food, education, and household needs. Anecdotally, farmers from groups that have been tilling the riverbed for five years or more reported that they have been able to accumulate enough capital to diversify into opportunities that offer a higher rate of return for their work. Some farmers are

investing in market center shops, such as cell phone repair shops; several are leasing increasingly large tracts of riverbed and hiring local wage laborers to till it. Although jobs created by riverbed farming are first taken by members of the immediate household, additional employment opportunities for other villagers are created in the medium term as farmers seek to lower the risk associated with being solely involved in farming by using their gains to diversify into other income opportunities.

The environmental indicators show that riverbed farming is a low external input technology with a large production potential and minimal negative environmental impacts. Per hectare, from 224 kilograms of inputs, just .01% of which came from off-farm (improved seeds, chemical inputs), riverbed cultivation generated 16,496 kilograms of vegetables. Riverbed farming does not require irrigation or energy besides human labor, uses minimal amounts of chemical fertilizers and pesticides, and generates zero waste, since it is all recycled on-farm. Farmers are trained in sustainable good agricultural practices like composting, seed selection and storage, and mulching. Spraying of chemical pesticides as necessary was reported in 9 of the 12 groups (anecdotal: once, maximum twice a season). Since the rivers change course every few years, requiring new pits or trenches to be dug, there is minimal danger of acidification of the soil, even if chemical fertilizers were to be over-used. Considering smallholders generally use their resources as efficiently as possible (IFAD 2013b), and as supported by anecdotal evidence, external input use is kept to a minimum as farmers seek to lower production costs. As crop vegetation and mulching cover the fine sand of the riverbeds, less wind erosion occurs so there is less dust in the air, helping to improve the local micro-climate. By anchoring the sand, the crops' root systems help structure the riverbed soil and increase its microbial activity.

The indicators for social sustainability focus on rural job creation and inclusion of females. Riverbed cultivation employs 24 people per hectare, who at the beginning are all from the farmers' immediate households. As farmers reinvest surplus income back into riverbed farming by leasing more land, their area under cultivation expands larger than the family can manage. Anecdotal evidence concerning migration underscores riverbed farming's contribution to creating sustainable rural employment opportunities. In 7 of the 9 villages from which male out-migration in search of work had previously occurred, it has slowed or ceased since the introduction of riverbed farming. Women represented 56% of riverbed farmers; they cited the proximity of the fields to the home as very important, highlighting the multiple roles females play domestically and as producers (FAO 2011).

The indicators of technological sustainability show that riverbed farming is an easy-to-learn technology that does not require land ownership, rendering initial investment costs low in terms of both physical and financial capital requirements. A total of $273.67 is needed as start-up costs per hectare ($37.07 for a household's 4 kattha; this includes the cost of the lease and inputs). Riverbed farming has one production cycle a year, and farmers can continue to produce indefinitely. All farmers reported that the technology is easy to learn and use, and that they applied new skills in their home gardens as well.

Together, low initial investments costs, ease of learning, and the possibility of a relatively high rate of return within the first season mean that neighboring farmers are replicating the riverbed farming technology independently. In 7 of the 12 villages visited, it was observed that neighbors had begun their own riverbed farming plots.

Conclusions and Outlook

Leasehold riverbed farming is a low-environmental-impact, easy-to-learn, cost-effective technology allowing landless households to produce on unused marginal lands. Riverbed farming avoids possibly thorny land tenure issues: not only is it based on a leasehold system, but by their very nature the rivers change course over time, rendering long-term investments in a specific part of the riverbed futile. In the short term, riverbed farming may increase farmers' vulnerability to environmental shocks. In the medium and long term, it increases households' resilience and creates rural employment opportunities. Extra income may be invested either in diversifying the households' income opportunities, such as buying a shop, or in a crop insurance scheme. Both increase households' options to adapt to the effects of climate change.

In the Terai, and elsewhere too, increasingly erratic hydrological patterns mean the riverbeds will continue to change course and grow broader, forcing more farmers to deal with the effects of climate change. By utilizing an under-exploited resource and enhancing smallholders' productive skills on marginal soils, riverbed farming increases marginal farmers' options for sustainably coping with the effects of environmental shocks like floods.

In sum, riverbed farming is an environmentally, economically, socially, and technologically sustainable technology that can contribute to creating rural employment opportunities and enhance marginal farmers' capacities to sustainably adapt to the effects of climate change.

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